INSTITUTE OF PETROLEUM REVIEW

5, No. 55. JULY 1951. Price 1/6d. Annual Subscription: Fifteen Shillings

PUBLIC LIBRARY
AUG 8 1951
DETROIT

TRADE ONLY

Eclipsol

LUBRICANTS

ECLIPSOL OIL CO. LTD.
ROEBUCK LANE WEST BROMWICH

PHONE:
WEST BROMWICH 0431-2-3-4

GRAMS:
SOLUBLE, WEST BROMWICH

PUBLISHED BY THE INSTITUTE OF PETROLEUM
6, Portland Place, London, W.1 . Telephone No. LANgham 2250

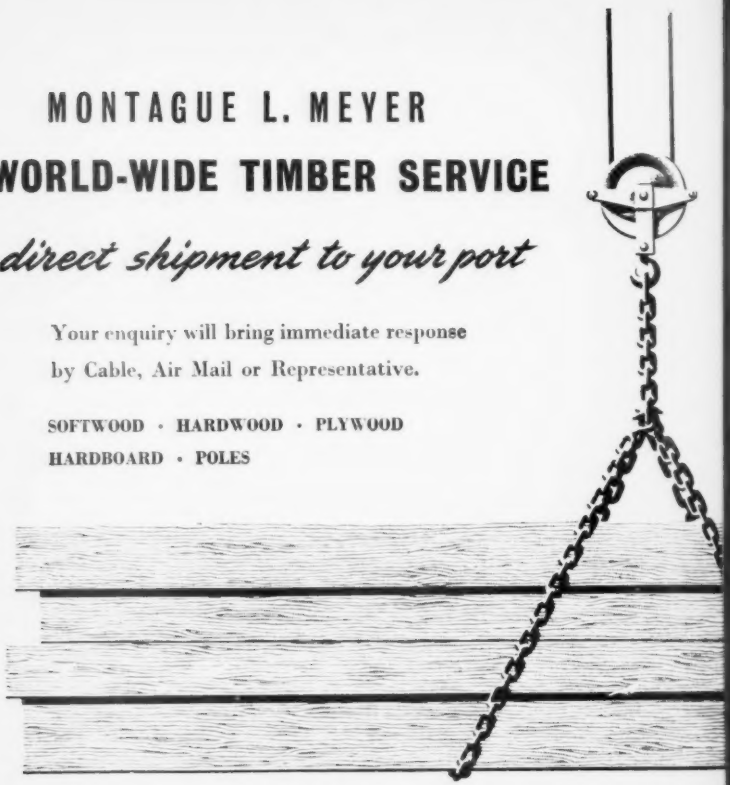
MONTAGUE L. MEYER

WORLD-WIDE TIMBER SERVICE

direct shipment to your port

Your enquiry will bring immediate response by Cable, Air Mail or Representative.

SOFTWOOD · HARDWOOD · PLYWOOD
HARDBOARD · POLES



MONTAGUE L. MEYER LTD.

Head Office: 14 BUCKINGHAM STREET,
ADELPHI, LONDON, W.C.2
'Phone: TRAfalgar 7766
'Grams and Cables: Emelemlid, Rand, London

Branches at Manchester, Birmingham, Hull, Southampton, Newport (Mon.)

INSTITUTE OF PETROLEUM REVIEW

Hon. Editor: F. H. Garner, O.B.E., PH.D., F.R.I.C.
Hon. Associate Editor: E. B. Evans, PH.D., M.SC., F.R.I.C.
Editor: George Sell

No. 55 JULY, 1951 Vol. 5

CONTENTS

MODERN TECHNIQUES IN TESTING PETROLEUM. I. DISTILLATION, BY S. A. ASHMORE AND D. S. VICKERY	210	U.S. PETROLEUM INDUSTRY	228
BRITISH OIL ENGINE EXPORTS	222	"ARCHIE"	229
AROUND THE BRANCHES	223	PETROLEUM IN PARLIAMENT	230
DIESEL LOCOMOTIVE 10100	227	"KNOW-HOW"	232
		PERSONAL NOTES	233
		U.K. PETROLEUM CONSUMPTION	234

MODERN TECHNIQUES IN PETROLEUM TESTING

Over the period July 1949 to July 1950, the *I.P. Review* presented a series of articles on the "Significance of the Properties of Petroleum Products." In view of the interest shown and because of the popularity of this series, it was decided by the Papers Sub-Committee to publish a further series dealing with modern methods employed in the analysis and testing of petroleum and its products.

The main object of this series will be to review the advances in laboratory apparatus, methods and procedure which have been made available for analytical and testing purposes during the last ten years.

The articles are intended to outline the latest developments in the realms of analysis and testing and will be presented in the following approximate order:—

I. Distillation.
II. Spectroscopy.
III. Gas analysis.
IV. Estimation of sulphur.
V. Engine testing of fuels.
VI. Engine testing of lubricants.
VII. Physical measurements such as:
  (a) Boiling point, specific gravity, refractive index, colour, surface tension, etc.;
  (b) Viscosity;
  (c) Electron diffraction, electron microscope, X-Ray examination
VIII. Inorganic analysis.
IX. Mechanical and other tests:
  (a) For lubricants and waxes;
  (b) For heavy fuels.
X. Micro techniques.
XI. Miscellaneous laboratory equipment.

MODERN TECHNIQUES IN PETROLEUM TESTING

I. DISTILLATION

By S. A. ASHMORE *and* D. S. VICKERY (Assoc. Fellow)

The value and Significance of Distillation Tests.

In reviews on process equipment for the oil industry distillation is generally highly placed [1, 2, 3]. Further, distillation equipment represents about 25 per cent of the capital investment of a refinery; consequently the importance of distillation is obvious and the need for all concerned in the industry to have some appreciation of what is involved in the science of distillation is apparent.

Testing is required to check that operation is satisfactory, i.e., that the product will be on grade. Routine control distillations are designed to cover this field. Secondly, though increasing use is being made of calculations based on vapour liquid equilibrium curves for designing fractionating equipment, it is not yet possible to dispense with data obtained from analytical laboratory distillations. A laboratory fractional distillation will indicate that a certain percentage of material may be obtained from a given feedstock and will indicate the purity which can be expected. On the other hand, vapour-liquid equilibrium data, e.g. from Othmer stills, usually only apply to fairly simple systems of a limited number of components and frequently are not very helpful when dealing with petroleum fractions. Further, it is not only the plant designer who requires analytical distillations but the refinery supervisor who requires a yardstick for his full size columns. It will be appreciated that in most of these cases, time is an important factor and it is essential that the maximum amount of information is made available rapidly. This aspect of analytical distillation technique is one that is rarely stressed sufficiently.

If a laboratory batch distillation on a column of known separation efficiency (i.e. known number of theoretical plates or transfer stages) gives a certain result the plant designer can then transpose these results into terms of continuous columns. The plant designer can, within certain limits, change from high number of plates and low reflux ratio to a low number of plates and high reflux ratio[4].

It is frequently desired to run a column above design capacity. Refinery staff will appreciate that in the old days nobody felt satisfied with a column until it had handled at least twice design throughput. Naturally a considerable number of factors are involved by such an increase, such as heater load, separation efficiency, cooling water consumption. But as far as the distillation column itself was concerned, plant designers tended to be liberal in their estimates, and built in ample capacity, so as to be on the safe side. Now that the design engineers are becoming more precise, such liberties cannot be taken without exacting a penalty. Still, even to-day, a considerable margin is left for ingenuity.

The importance of an accurate design is very high, as in a big refinery the inclusion of the maximum amount of a valuable product in, say, the overhead stream, which is blended in with the gasoline fraction as against putting it in the bottoms, which form a distillate fuel, may represent a daily saving of some hundreds of pounds. Sharp fractionation enables us to sharpen the line of demarcation between top product and bottom product and adequate analytical distillation facilities enable the plant manager to know if he is in

fact operating under the best conditions or if he has slipped away from the optimum point.

The additional information obtained from an analytical fractionation test, as compared with a standard distillation test, (I.P. 123) is shown in Fig. 1. If the respective curves relating boiling point with per cent volume distilled be compared it will be seen that in the analytical distillation the existence of two major boiling point "flats" is revealed and also the presence of 10 per cent material boiling below the I.B.P. given by I.P. 123. From the analytical distillation, samples can be obtained which will indicate what materials are present in the charge more clearly than was possible with the Engler distillation; in fact the compounds may be identifiable from boiling point alone. In addition by carrying out refractive index determinations on the fractions from the analytical run a further insight is gained into the composition of the material. Thus, in Fig. 1 the refractive indices indicate clearly that the slopes in the boiling point curve between the "flats," are due to the presence of intermediate compounds of high refractive index. The slopes are not caused by poor fractionation, or simple mixture of the materials of low refractive index, which would otherwise be the probable interpretation of the true boiling point curve. This technique of applying tests on the distillate fractions to supplement the information given by the distillation itself is very common, as the supplementary tests if simple enough, can be carried out while the distillation is in progress so that the limiting time factor is only the distillation itself. Fig. 2 shows the use of aniline point to supplement the distillation data on a sample of crude *iso*-octane. This enables the end of the "flat" of 2,2,4-tri-methylpentane (aniline point 79°C) to be seen more clearly than would be the case using boiling point alone or refractive index alone. It also indicates that we have certain materials of low aniline point boiling between the two major boiling point "flats," and that the slope at 45 per cent volume is due to the presence of these compounds, not a simple transition between the two major constituents. Further, the drop in aniline point between 50 per cent volume and 80 per cent volume confirms the fact that we are here dealing with a mixture of compounds and not a single component. These components have boiling points very close together and

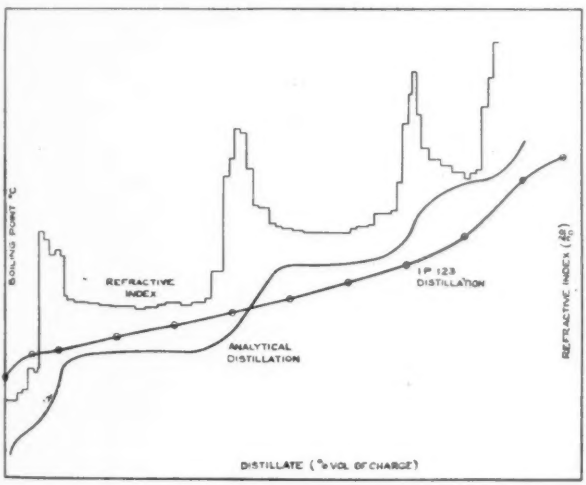


Fig. 1.

cannot be separated by distillation in this column.

Theoretical Considerations

The significance of fractional distillation tests in petroleum testing and refining having been explained, it is now proposed to give a brief outline of the theory underlying the process and its application to fractionating apparatus.

For simplicity the case will be considered of a binary mixture of two completely miscible liquids A and B, of which the boiling point of component B is lower than the boiling point of component A. In general when such a mixture is heated the vapour evolved will usually be richer in the lower boiling component than the original mixture. If these vapours are removed and condensed the condensate will contain a greater proportion of the lower boiling component and the remaining liquid more of the higher boiling component.

It should, therefore, be possible by an extended series of simple distillations to effect a separation of the two components but this cumbersome and time consuming process is rendered unnecessary by the use of a fractionating column which can effect a separation in one operation.

Since, however, there are exceptions to the above behaviour it is important that consideration be given to the changes in vapour pressure of such mixtures following any alteration in composition and to examine the vapour pressure/composition relationships. The vapour pressure of each component of miscible liquids is lowered by the presence of the other so that the total vapour pressure of the mixture is less than the sum of the vapour pressures of the components at any one temperature. As a rule the curve showing the relation between the vapour pressure of a mixture and the composition of the liquid may be referred to one or other of the three types shown in Fig. 3.

The abscissae give the composition of mixture and the ordinates the corresponding vapour pressures.

It will be evident that the vapour pressure/composition relationships differ considerably for the three kinds of mixture represented by Curves I, II and III.

In Curve I it will be seen that for one particular liquid composition (R) the vapour pressure is a minimum corresponding to a maximum boiling point in excess of that of either component. In Curve II for another particular liquid composition (T) a maximum vapour pressure is indicated corresponding to a minimum boiling point lower than that of either com-

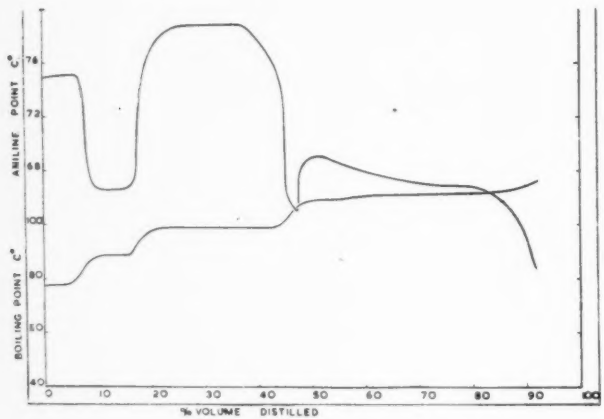


Fig. 2.

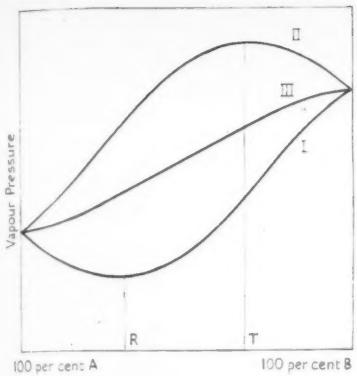


Fig. 3.

ponent. These mixtures are termed azeotropes and the components cannot be separated by fractional distillation because the boiling point of the mixture rises or falls to the maximum or minimum. At this point there is distillation to give a mixed distillate of constant composition R or T until the main component of the azeotrope has been consumed, after which the temperature rises to the boiling point of the other component.

In Curve III there is no evidence of azeotrope formation and such a mixture is found to obey Raoults law which states that if one volatile liquid is dissolved in a volatile solvent the lowering of the partial pressure of the solvent is proportional to the molar fraction of the dissolved substance. The relation may be expressed by the equation

$$p = p_o x_o$$

Where p is the partial vapour pressure of the solvent, p_o the vapour pressure of the pure solvent, and x_o is the molar fraction of the solvent in the mixture.

This mixture represents what is known as an "ideal" system of liquids and with suitable equipment it can be separated into its components by fractional distillation.

The separation by fractional distillation of any two liquids showing ideality consists essentially of a series of distillations in which the vapour phase becomes progressively richer in the more volatile component and the liquid phase richer in the less volatile component. For this reason a knowledge of the vapour/liquid equilibrium of the two liquids at a specified pressure is an important consideration affecting the choice or design of a fractionating column for their separation. These data are frequently shown in the form of a diagram in which the molar percentage of the more volatile component in the vapour is plotted against the equilibrium concentration, also expressed as a molar percentage of the same component in the liquid phase.

The molar percentage of a component can be calculated from its percentage by weight as follows:

Let a = weight per cent of component A of molecular weight M_A

Let b = weight per cent of a component B of molecular weight M_B. Then the molar percentage X_A of component A is

$$X_A = \frac{100 \dfrac{a}{M_A}}{\dfrac{a}{M_A} + \dfrac{b}{M_B}}$$

Fig. 4 is a diagram of the vapour/liquid equilibrium curve for benzene and toluene mixtures.

The dotted diagonal line shows the amount of benzene in the liquid and the curved line the amount of benzene in the vapour. Thus for example a mixture of 50 molar per cent benzene and 50 molar per cent of toluene would on boiling give a vapour containing 72 per cent of benzene. If this vapour is condensed the liquid obtained will show a benzene enrichment to this extent brought about by a one-plate distillation.

The deviation of the curved line from

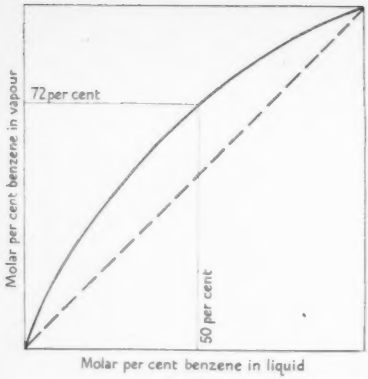


Fig. 4.

the diagonal is a measure of the ease of separation since, if there were no difference in the composition of the liquid and vapour phases, the curve would correspond to the dotted diagonal line and no vapour enrichment on distillation would be possible.

Furthermore, since, generally speaking, the component with the higher vapour pressure occurs in greatest concentration in the vapour phase, it follows that the greater the difference in the boiling points of the components, the more easily can they be separated by fractional distillation.

The data needed for constructing the diagram shown in Fig. 4 may be obtained comparatively simply from curves relating the boiling points of different mixtures with their composition. With more complex mixtures however the composition of the vapour must be determined by suitable analytical methods.

The above considerations show in brief outline the theory underlying the process of fractional distillation. For more detailed information the reader is referred to "Elements of Fractional Distillation" by Robinson and Gilliland and "Principles of Chemical Engineering" by Walker, Lewis and McAdam.

The Fractionating Unit and its Operation

The separation of liquids by fractional distillation in the laboratory is generally done by the batch or intermittent process, although the alternative continuous process may sometimes be employed. In the batch process the mixture is vaporized in a still connected to a fractionating column on which is mounted a column head. The column head condenses the vapours and the liquid is either wholly returned to the column or at the appropriate time divided by a proportionating device, whereby the more volatile component is withdrawn as distillate, the less volatile component remaining in the still. The continuous process utilizes much the same apparatus except that the still is usually replaced by a small heating vessel called a reboiler. The mixed liquids to be separated are fed directly into the column at some point along its length, the heat necessary to vaporize the feed being supplied from the reboiler. By this means a complete separation of the components is continuously effected in the column, the more volatile component being removed at the top of the column as an overhead product while the less volatile component is withdrawn from a point near the bottom of the column.

In either process a number of special terms are used having the following meanings:

Reflux. The condensate that returns to the column and flows counter-current to the vapour stream.

Boil-up Rate. The amount of liquid vaporized from the still to the column in unit time. This is usually determined from the measurement, in some form of meter set between still and column, of the amount of descending reflux. Boil-up rates from 200 ml/hour to 2000 ml/hour, depending among other things on the diameter of the column, are generally used in laboratory fractionation.

Reflux Ratio. The ratio of the total amount of condensate returned to the column to the amount removed overhead as distillate both referred to the same unit time. Thus, if the boil-up rate is 400 ml/hour and there are no heat losses, and the rate of distillate withdrawal 20 ml/hour, the reflux ratio will be 19: 1 since (400-20) ml/hour return to the column.

Total reflux. The process in which all the condensate is returned to the column and none withdrawn as distillate.

Hold-up. The amount of liquid retained in the distillation column. This can be of two kinds: (1) the static hold-up which is the amount of liquid required to wet the column packing; and (2) the dynamic hold-up which is the amount of liquid held in the packing during a distillation. The dynamic hold-up is generally considerably greater than the static hold-up.

Rectification. The basis of efficient fractionation where a high degree of separation is required. Reflux descending the column is brought into intimate contact with the ascending vapours whereby, as a result of thermal interchange, there is a constant exchange of the less volatile component for the more volatile component as the vapour rises through the column.

Pressure Drop. The difference in pressure exerted by the vapour entering the column base to that of the vapour leaving the column head as measured by a manometer. This figure is generally small with columns working at atmospheric pressure but at reduced pressure it may increase considerably owing to resistance of the packing.

Relative Volatility. For an "ideal" binary mixture this is the ratio of the vapour pressures of the pure components.

As batch distillation is more commonly used in laboratory practice the sequence of operations in a batch fractionating unit will now be described. Although later the design and construction of fractionating apparatus is discussed in detail it may be helpful in following the operation of the unit to enumerate the essential features of still, column and column head.

Apparatus for laboratory fractionation is generally made of glass, although other materials may be used in the construction of larger than laboratory scale units.

Still. The still, whose function is to vaporize the charge, has a capacity of approximately twice that of the charge to be fractionated. Some form of electric heating is generally used and fine control over the heat input is necessary to ensure a steady boil-up rate.

Fractionating Column. This column consists of a glass tube containing a device for effecting intimate contact between vapour and liquid and having outside some form of heat insulation.

Column Head. The column head consists of one or more condensers, a reflux proportioning device and a thermometer for recording the temperature of the vapours. In Fig. 5 is shown a simple column head with two condensers, one for vapours providing the reflux, the other for cooling the distillate withdrawn from the head, and a stopcock to proportionate the reflux.

Operation of Fractionating Unit

The sequence of operations refers to the separation of three liquids A, B, and C of successively increasing boiling point.

A known volume of the mixture, which should not be less than approximately twenty times the hold-up of the unit, is transferred to the still and the product withdrawal tap on the stillhead closed. The mixture is vaporized through the column and the vapours condensed to liquid in the stillhead are wholly returned down the column. When the packing is thoroughly wetted

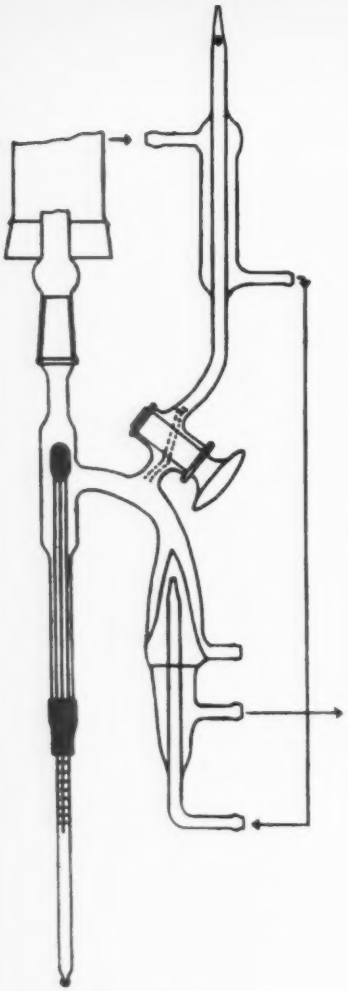


Fig. 5.

the boil-up rate is adjusted to a predetermined figure and the column is allowed to remain under total reflux for a period which may vary from one to several hours, depending on the efficiency of the column in relation to the difficulty of separation of the liquids.

As a result of heat interchange brought about in the column during this time there has been a gradual enrichment of the ascending vapour with the lowest boiling constituent A, until finally this constituent alone is present at the top of the column and the still head thermometer will record a temperature corresponding to the boiling point of pure liquid A. This can now be removed through the tap of the reflux divider at a rate governed by the reflux ratio deemed necessary for this separation. When nearly all constituent A has been removed in this way the thermometer will show a rise in temperature, which is an indication that small amounts of the next higher boiling constituent B are present in the vapours at the top of the column. The receiver containing pure liquid A is now replaced and at the same time the reflux ratio is increased by adjusting the tap to reduce rate of withdrawal of distillate. The next fraction, which should be small and is called an "intermediate," is collected during the period in which the temperature on the still head thermometer shows a gradual rise to, and finally remains steady at, the boiling point of pure liquid B. The receiver is again changed and the reflux ratio readjusted to its original value, when pure liquid B is collected until another gradual rise in temperature shows that its removal is nearly complete. If liquid C is required as an overhead distillate the above procedure must be repeated.

The Efficiency of Fractionating Columns

The efficiency of a laboratory fractionating column is often expressed in terms of the number of equivalent theoretical plates it contains.

The theoretical plate is a concept based on vapour/liquid equilibrium, and may be defined as that section of a column in which contact between vapour and liquid is so good that the vapour

leaving the section has the same composition as the vapour in equilibrium with the liquid in the section.

Since columns vary in length, a basis of comparison sometimes used is the height of a column section which will effect equilibrium between vapour and liquid. By definition this will be the height necessary to make a separation equivalent to the separation effected by one theoretical plate and is referred to as the H.E.T.P. (height equivalent to a theoretical plate). It is numerically the quotient obtained by dividing the length of the column packing, in inches or centimetres, by the number of theoretical plates.

A knowledge of the efficiency of a column in terms of theoretical plates is often a useful guide in the selection of a column since for a simple system of liquids the minimum number of plates required to effect a separation can be calculated if vapour pressure data for the components are available[5].

The number of theoretical plates is usually measured at total reflux. The measurement is always made at a known boil-up rate since the number of plates varies with this and may reach an optimum value. A binary mixture of liquids is chosen having the following characteristics (1) the boiling points of the components must not be more than two to three degrees apart, (2) it must be as near as possible an "ideal" system (3) analysis of the mixture should be simple and rapid; the refractive index measurement is convenient for this purpose providing there is sufficient difference in the values of this constant for the two components. The physical properties of two pairs of liquids which satisfy these requirements is shown in Table 1.

The procedure is to charge the still with one of the above binary mixtures, distil at a known boil-up rate under total reflux until the column is in equilibrium, and then take simultaneous samples of reflux from above and below the packing for analysis. In practice the samples are usually taken from the reflux head and the still. The refractive index of each sample is then measured.

TABLE

	Boiling Point (°C)	*Refractive Index* ($\mu_{20°}$)	*Relative Volatility*
Benzene	80.1	1.5008	1.110
Ethylene dichloride	83.7	1.4447	
n-Heptane	98.4	1.3878	1.083
Methylcyclohexane	100.3	1.4232	

From the data so obtained the number of theoretical plates may be determined either by the graphical method of McCabe and Thiele[6] or from Fenske's equation[7] for a binary mixture under total reflux.

Graphical Method of McCabe and Thiele.

Although this method is somewhat tedious to apply and is inaccurate if used for testing columns of more than approximately 30 theoretical plates, it has the merit of supplying a background for a correct appreciation of the changes taking place in a fractionating column. As a result it is possible further to visualize the concept of efficiency of a plate and thus understand the performance of a bubble cap column.

It must be emphasized that the method is strictly applicable only to continuous columns under total reflux but may be used for batch distillation with columns working under total or partial reflux, providing the volume of liquid in the still is large compared with that in the column.

The method is based upon the vapour/liquid equilibrium diagram of the binary mixture. In Fig. 4 was shown a vapour/liquid equilibrium diagram for benzene/toluene mixtures and a similar diagram is constructed from data for the binary mixture used in testing the column. By using the diagonal as a datum line a number of horizontal "steps" can be drawn between this line and the equilibrium curve from which the composition of liquid and vapour on each plate can be determined. The number of "steps"

required to proceed from the composition of the liquid at the top of the packing to the composition of the liquid at the bottom of the packing, each expressed in terms of the molar proportion of the more volatile component, is equal to the number of theoretical plates for that separation. From the results obtained one theoretical plate is deducted to allow for the stage from still to column.

Fenske's Equation.

This is applicable for a binary mixture under total reflux.

If n = the number of theoretical plates in the column,

x' = the molar concentration of the more volatile component,

x'' = the molar concentration of the less volatile component, and

α = the relative volatility of the two components, then

$$n = \left[\log \left(\frac{x'}{x''}\right)_T \left(\frac{x''}{x'}\right)_B\right] \Big/ \log \alpha$$

Where the subscripts T and B refer to the top and the bottom of the packing respectively.

An example of the method is given in the following results of test on a packed column of medium efficiency using a mixture of benzene and ethylene dichloride. The boil-up rate was 200 ml per hour. The refractive index at 20°C of samples taken from the reflux head and still were respectively 1.4780 and 1.4485 from which it was calculated that they had the following composition expressed as a molar proportion.

	Top of Packing	*Bottom of Packing*
Benzene	0.64 mol	0.10 mol
Ethylene dichloride	0.36 mol	0.90 mol

The number of theoretical plates calculated from these data is 27. By making the usual deduction of one theoretical plate to allow for the stage from still to column this value becomes 26.

In the above method the column has been tested under total reflux and the results so obtained are in general related to the performance of the column under normal operating conditions in which obviously partial reflux, or a reflux ratio is used. It is however sometimes useful to know the number of equivalent theoretical plates at a known reflux ratio and this may be computed by the use of equations due to either Dodge and Huffman[8] or Smoker[9] or it may be done empirically.

The above considerations are all based upon the concept of the theoretical plate and the operations in a fractionating column are visualized as taking place in a series of stages at each of which there is equilibrium between vapour and liquid. This view has been criticized by some workers who prefer to regard the system as one in which the vapour passing upward and through a section of the column becomes progressively richer in the more volatile component and the liquid passing down becomes progressively richer in the less volatile component. On this basis Chilton and Colburn[10] have introduced the idea of transfer units and measure the efficiency of a column in terms of H.T.U. (height equivalent of a transfer unit) instead of H.E.T.P. The determination of transfer units is done in the same way as theoretical plates, and in deriving an expression to represent the number of transfer units in a column at total reflux they assume that evaporation and condensation at the liquid interface proceeds so rapidly that the surface layer of vapour is always in equilibrium with the liquid and the only resistance to change of material is that of diffusion in the vapour stage.

Although the efficiency of laboratory columns may be compared either in terms of H.E.T.P. or H.T.U., it is of interest to note that the conditions of material transfer postulated in the work of Chilton and Colburn have of recent years been embodied in a number of

formulae of use in calculations relative to the design of full scale columns

While with a batch distillation column the efficiency in terms of number of theoretical plates or H.E.T.P. is a valuable guide, this should always be considered in relation to its hold-up. The hold-up can effect not only the efficiency of separation but also the time required for a distillation and this is clearly an important economic consideration.

The effect of hold-up, which has been investigated theoretically[11], may be shown in the following way. In the separation by fractionation of two liquids A and B, of which A is the more volatile, the whole of A cannot be recovered in the pure state since some will be present in an intermediate fraction consisting of a mixture of A and B. Providing such factors as the number of plates and reflux ratio remain unaltered the percentage amount of liquid A recovered will increase as the ratio of total charge to hold-up is increased. As a result of experience a now commonly adopted rule is that the still charge should be at least twenty times the hold-up.

From the above considerations it will be evident that to obtain the same degree of separation with two columns which have the same number of theoretical plates and are worked at the same reflux ratio, the column with the greater hold-up will require more charge and hence a longer time for distillation.

Several workers have embodied the above considerations in an overall cypher relating efficiency in terms of theoretical plates, boil-up rate and hold-up. In one, called a hold-up factor, it is expressed as ml of hold-up per theoretical plate divided by the operating boil-up rate in ml per second[12]. It is suggested that the most economical conditions under which the column should be operated are those at which the hold-up factor is a minimum and further that this factor is directly proportional to the time required for a distillation at a known efficiency. Other similar factors have been derived[13, 14].

Special Methods of Fractional Distillation

The underlying principles of vacuum distillation, azeotropic distillation and extractive distillation will now be briefly considered together with, in some cases, examples of the use of these processes in the petroleum industry.

Vacuum Distillation. — By suitable modification a degree of vacuum is applied to either batch or continuous type apparatus whereby the distillation is carried out at some pressure less than atmospheric. This is a vacuum distillation and a number of considerations determine its suitability or otherwise for separating the constituents of a mixture.

In commenting on the vapour/liquid equilibrium diagram (Fig. 4) it was stated that the extent of the deviation of the curve from the diagonal was a measure of the ease of separation of the components. If at a reduced pressure the curve for any particular mixture shows a deviation greater than that obtaining at atmospheric pressure then the use of vacuum will facilitate the separation. A further advantage, often of great importance with petroleum products, is that the lower temperatures used in vacuum distillation may prevent or minimize losses due to thermal cracking.

Azeotropic Distillation. — The components of certain mixed liquids cannot be separated by straight fractional distillation either because their boiling points are too close together or they form an azeotropic mixture. By the addition of a third substance, sometimes referred to as an entrainer, the separation can then be effected and this process is termed azeotropic distillation.

The entrainer functions by virtue of the fact that it affects the relative volatilities of the components. It may form

azeotropes with one or more of the components whose relative volatilities, and therefore boiling points, now differ sufficiently to allow separation by fractional distillation. After separation of the azeotropes in this way, removal of the entrainer leaves the pure component. Other features which the entrainer must have, are a suitable boiling point and some property by which it may be readily separated from the entrained substance, e.g. limited miscibility with the latter or solubility in water.

Azeotropic distillation, which can be done in either batch or continuous apparatus, is of special value when it is necessary to isolate or prepare a compound in a degree of purity that cannot be achieved by ordinary fractional distillation. It is thus applied mainly to systems that can be regarded as essentially two component systems, apart from the third material specifically added, though one "component" may be a complex mixture such as gasoline. An example of this is the separation of toluene from gasoline, a process carried out on a large scale during the recent war when it became necessary to augment supplies of toluene[15]. A close cut fraction (100-115° C) of gasoline, containing from ten to twenty per cent of toluene was mixed with methyl alcohol and fed to a continuous fractionating column. The paraffins associated with the toluene formed azeotropes of lower boiling point than any other components in the system and could be removed as an overhead distillate, while a concentrate containing from 96 to 98 per cent toluene was obtained as a bottoms product which, after an acid wash was redistilled to give pure toluene of nitration grade quality.

Extractive Distillation. — In practice extractive distillation is used for much the same purpose as azeotropic distillation and in theory there is little difference in the two processes, since both depend on modifying the relative volatility of the components.

The process is carried out with a continuous fractionating apparatus and the feed containing the components to be separated is introduced into the column at some intermediate point along its length. At the same time a suitable solvent is allowed to flow down the column and in scrubbing the vapours one component is preferentially absorbed. The vapour pressure of the dissolved component is thus reduced and the effect of this is to increase the value of α, the relative volatility, and so make the separation easier. If, for example, toluene is to be separated from the close boiling paraffins with which it is associated in gasoline fractions the relative volatility of the components may be taken as 1.0; on the addition of phenol as solvent the relative volatility is increased to 3.7 corresponding to a difference in boiling point of about 80° C. The components whose vapour pressures are least affected are obtained as overhead products while the other component remains in the solvent and leaves the system as a bottom product. The solvent is separated from this component, either by redistillation, cooling or water washing and is then re-cycled through the column. Features which the solvent must possess are thermal stability, a suitable boiling point in relation to the volatility of the more volatile component, and miscibility with the feed and its components at the temperatures obtaining in this column.

A typical cycle of these operations, showing the separation of benzene (boiling point 80.1° C) and *cyclo*hexane (boiling point 80.9° C) is given diagrammatically in Fig. 6. The solvent used is phenol and *cyclo*hexane is separated as an overhead distillate while benzene dissolved in phenol is withdrawn as a bottom product. This is steam distilled to separate benzene and the phenol is recycled to the column.

The technique of extractive distillation, similarly to azeotropic distillation, has found its main application in the

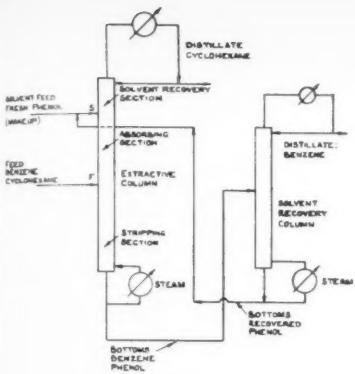


Fig. 6.

separation of one compound from a complex mixture. Thus it has been used for separating toluene from petroleum fractions[16] using phenol as solvent, while for the separation of butadiene from its associated C_4 hydrocarbons, butenes and butanes, the solvent used was furfural[17].

By comparison with azeotropic distillation the process of extractive distillation is more difficult to carry out in the laboratory. It has, however, considerable possibilities and should be regarded as a valuable tool. The question of energy consumption for the two systems is rarely of importance in small scale work, but where it is, specific cases must be considered, as generalization is impossible.

REFERENCES

1 *Refiner*, 1947, **26** (4), 141.

2 Edmister, W. C. *Refiner*, 1948, **27** (9), 2.

3 Edmister, W. C. *Refiner*, 1949, **28** (9) 94.

4 Rose, A., and Welshans, L. M. *Industr. Engng Chem.*, 1940, **32**, 668.

5 Rose, A. *Industr. Engng Chem.*, 1941, **33**, 594.

6 McCabe, W. L., and Thiele, E. W. *Industr. Engng Chem.*, 1925, **17**, 605.

7 Fenske, M. R. *Industr. Engng Chem.*, 1932, **24**, 482.

8 Dodge, B. F., and Huffman, J. R *Industr. Engng Chem.*, 1937, **29**, 1434.

9 Smoker, *Amer. Inst. Chem. Engrs*, 1938, **34**, 165.

10 Chilton, T. H., and Colburn, A. P. *Industr. Engng Chem.*, 1935, **27**, 255.

11 Rose, A., Welshans, L. M. and Long, H. H. *Industr. Engng Chem.*, 1940, **32**, 668, 673, 675.

12 Fay. *Ann. Repts. Prog. Chem.* (*Chem. Soc. London*), 1943, **40**, 216.

13 Podbielniak, W. J. *Industr. Engng Chem.* (*Anal.*), 1941, **13**, 639.

14 Stedman. *Can. J. Research*, 1937, **15**, B, 383.

15 Foster, A. L. *Oil Gas J.*, 1944, **42**, (49), 130.

16 Dunn, *et al. Trans. Amer. Inst. Chem. Engrs*, 1945, **41**, 631.

17 Happel, *et al. Trans. Amer. Inst. Chem. Engrs*, 1946, **42**, 189.

(*To be continued*)

★ ★ ★

FILMS ABOUT OIL

A number of interesting new titles appear in the 1951 catalogue of films available on loan from Petroleum Films Bureau. They include "Birth of an Oilfield" (Shell Petroleum) dealing, in colour, with modern techniques in drilling and production, Anglo-Iranian's "We've come a long way," a coloured cartoon showing the development of tankers from the sailing brigs of 1861 up to today, and the P.F.B's "Over the Road," which deals with accidents caused by careless road crossing.

On the processing side, there are Shell Petroleum's "Acid Treatment" and "Solvent Extraction," while utilization is stressed in "Oil and Industry," Shell-Mex and B.P's survey of the use of oil for transmitting power, as a lubricant, insulator, coolant and for quenching and rust prevention.

Enquiries should be addressed to the Bureau at 29, New Bond Street, London, W.1.

Directors of BOFEC with Mr Herbert Allen. (L. to R.) H. Wheeler, E. M. Benjamin, H. Allen, Alan P. Good, F. J. Fielding, Cyril F. Dennis, and Niels Matheson.

BRITISH OIL ENGINE EXPORTS

Recently Mr Alan Paul Good, chairman of British Oilfield Equipment Co. Ltd., gave a dinner in London to welcome Mr Herbert Allen, vice-president of the Cameron Ironworks Inc., and in honour of Their Excellencies the Members of the Corps Diplomatique.

In the course of his address, Mr Good said that the British Oilfield Equipment Co. had been founded some four years ago to meet the desire of oil companies to purchase certain of their equipment within the sterling area. There could be no doubt that the demand for oilfield equipment would increase throughout the world, and he felt it would be a long time before sterling and the dollar became freely convertible. Therefore, some oil equipment must be produced within the sterling area and the arrangements made with the Cameron Ironworks had been designed to cover these circumstances.

Referring to his recent world tour, Mr Good said that there was a big demand for all types of diesel engines and, in spite of material and other difficulties, Britain must increase its output to meet that demand. He had discussed the question with his colleagues in the Brush—ABOE Group and he was satisfied that it could and must be done.

In the last five years they had built up a trade of £750,000 per year with Pakistan, and over 20,000 small Petter engines had been delivered to India in the last two years. In Ceylon they had secured the biggest order ever placed in the U.K. for diesel-electric locomotives and they had secured over 50 per cent of the heavy oil engine market in Australia. With over £30,000,000 on their order book, they would have to double their output of small engines at Staines and of big engines at Mirrlees.

Concluding his speech, Mr Good said he was convinced that the future of the world depended primarily on the British and American nations co-operating to ensure that the countries of the world and food production are exploited only on the basis of our moral responsibility to do our utmost, expecting no vast profit other than a reasonable return for the risk undertaken.

The toast of "The Guests" was replied to by Mr Herbert Allen and by Sir Archibald Rowlands, G.C.B., M.B.E., Permanent Secretary, Ministry of Supply.

The British Oilfield Equipment Co. Ltd. was toasted by Lt-Col. S. J. M. Auld, O.B.E., M.C., D.Sc., F.Inst.Pet., and replied to by Mr E. Benjamin, managing director.

At the end of the evening the guests were entertained with a "Cabaret in Cameo" devised by Cyril Dennis, M.Inst.Pet.

AROUND THE BRANCHES

London Branch

On the evening of April 18 a large audience gathered at Manson House to hear Lt-Col. S. J. M. Auld, O.B.E., M.C., D.Sc., read a paper entitled "Petroleum in Industry. V-Marine". Due to too close inspection of the operating end of a fire extinguisher the chairman was not able to be present and the vice-chairman, A. W. Deller, presided.

Col. Auld, whose paper was illustrated by a comprehensive selection of lantern slides, gave an impressive survey of the applications of fuel oil and lubricants to ships in an easy style which belied the immense amount of information contained in the paper. The lecturer started off by dealing, with a wealth of practical detail, with the classic use of fuel oil as boiler fuel, followed by an extensive and very interesting description of the marine gas turbine. He then turned to the fuel requirements of the diesel engine (which propels no less than one quarter of the world's tonnage), mentioning in particular the possibilities, which had been opened up by a series of experiments in tankers of the Anglo-Saxon Petroleum Company Limited, of getting away from the relatively expensive distillate fuels and using instead much heavier mixed fuels and residual fuels which have been specially centrifuged.

Col. Auld then went on to discuss the varied and rather specialized problems of lubricating, first of all, reciprocating steam engines and then steam turbines, and finished with a brief treatment of marine diesel lubrication.

At the end of this exceptionally interesting paper there was an enthusiastic reception for a vote of thanks proposed by G. E. Roberts.

Buffet Supper

From the meeting members and visitors moved quickly in the direction of the bar and cold buffet which were the focal points of the Branch's second winter social function. The Chairman, N. E. F. Hitchcock, having emerged from the foam, was present to welcome the large company. Those who were quick enough were then able to satisfy hunger as well as thirst in time for a programme of documentary films starting with "Come Saturday," an entertaining description of the varied ways in which English people spend that rather rare phenomenon—a fine Saturday. This was followed by "River to Cross," which gave a fascinating insight into the problems of designing a large suspension bridge. Finally, after an interval, was shown "Isle of Man T.T. 1950," a record of last year's motorcycle Tourist Trophy races.

The attendance was well over 100 and it was generally felt that an informal evening of this sort provided an agreeable opportunity to meet and talk with one's friends in the Branch and others from outside.

Film Show

The last meeting of the 1950/1 session of the London Branch took the form of a film show of which the principal feature was "Louisiana Story". Due to the kindness of Unilever Limited, the meeting was held in the admirable little cinema in Unilever House. The Branch chairman, N. E. F. Hitchcock, presided. In introducing the films, the vice-chairman, A. W. Deller, expressed the thanks of the Branch to Unilever and their Documentary Film Supervisor, Mr Mitchell, as well as to the Esso Petroleum Co. Ltd., who through the efforts of Mr Lawson Dick of their Public Relations Department had arranged the necessary permissions for the film to be shown.

The show opened with a Cinemagazine consisting of four short items of general interest. Then followed "Louisiana Story," which was made by

Robert Flaherty for the Standard Oil Company (New Jersey). It is an outstanding documentary film, set in the Louisiana "bayous," and contains some of the most dramatic drilling shots ever seen. With authentic sound effects as a background, the film conveyed a powerful impression of the drilling of a major well; a pleasing feature of the film, also, was the charming picture of the life of people in this little-known part of the United States. After the show a number of members joined the Committee in an informal supper at the "Cock" Tavern in Fleet Street.

The demand for seats was such that a second showing was arranged and took place on May 17; this was also followed by an informal supper.

South Wales Branch

The seventh meeting of the session was held at Llandarcy on March 8, 1951, at which a Symposium was presented by C. A. Simpson, supported by W. E. Evans, M. E. Thomas and E. J. Jones.

Mr Southall, in the unavoidable absence of the Branch Chairman, took the Chair.

In opening the proceedings, Mr Simpson intimated that the objective was to give some idea of the organization of an accounts department of an oil company and also of some details required for a petroleum refinery. Obviously, this must be on very broad lines. He dealt generally with the organization as it existed at Llandarcy, and the chain of control from the control point, London, explaining briefly how and why the various sections of the department were split and how they linked up, giving an outline of their duties, stating that a more complete picture would be given of certain sections, such as costs, oil stocks and general, by his collaborators.

W. E. Evans dealt with the costing section, explaining the various classifications and splits in wages, direct materials, purchases, power steam and water, rents, rates and insurance etc., and further, that in all cases, for check purposes, there was a control account. He then explained how everything was broken down and given a job number. He also dealt with the building up of necessary monthly statements and in a very general way dealt with budgetary control.

M. E. Thomas followed, dealing with the oil stocks section. He outlined the method of control of movement of liquid products and the checking of quantities by physical measurement. He described briefly, the method of handling receipts of crude oil, right through refinery operations to the finished products and the ultimate balancing of imputs against outputs. Mr Thomas summarized the methods of stock keeping and referred briefly to operations in connexion with Customs and Excise.

E. J. Jones, then described the operations of the general section, which in the main, co-ordinated all other sections of the accounts department in such a way that, with the co-operation of other departments, outside accounts, true cost and financial statements of process operations, process and engineering expenditure were produced. He described the main types of statements which were necessary from the budgetary point of view to be produced both for local use and for general information of the directors. He discussed briefly, financial estimating for budgetary purposes.

Mr Simpson, in closing the proceedings, pointed out that the picture given was quite a small one and time did not allow a more detailed account of other sections, nor had mention been made of the various problems and difficulties which had to be overcome. He further stated that although the particulars given may be the general organization of an oil company, he would like to make it quite clear, that

in this instance, it was essentially as carried out at Llandarcy.

A lively discussion followed. Amongst those who took part were, Messrs Vivian, R. A. F. Lee, I. Cameron, M. Y. Muirhead, Ragione and S. Griffiths.

Vote of thanks was proposed by H. W. Murphy and Seconded by T. L. Williams.

The eighth meeting of the session was held at Llandarcy on April 12, under the Chairmanship of Mr I. Cameron, at which a talk was given by F. V. M. Bell, general superintendent construction, National Oil Refineries Limited, under the title "Some Engineering Aspects of Llandarcy Refinery Expansion Project."

Mr Bell in the course of his talk stated that Llandarcy refinery started operations in 1921 on a throughput of 1,000 tons per day. To make this possible five wooden jetties were built at Queens Dock, Swansea, and the necessary pipe-track laid to bring in the transit site storage tanks and to couple them up with the main storage tanks some three miles away; in addition the early refinery consisted of some five distillation units of the shell-still type plus the usual treating plants in common use at that time. In 1930 two tube still vacuum distillation units were added to permit the preparation of heavy waxy lubricating oils for further processing and immediately prior to 1939 a modern combination tube still distillation unit had been added coupled with a new solvent dewaxing and refining unit and a high temperature clay treatment plant. With all these additions, however, the throughput at Llandarcy had remained steady. The present expansion project involved the addition of new refinery equipment of greatly increased capacity, and by 1954 it is envisaged that the project will be nearing completion, and that a throughput ranging from $2\frac{1}{2}$ to 3 million tons per annum will be maintained.

To make this possible it has been necessary to re-design the jetty facilities at Queens Dock, to extend the storage site, and to prepare for the addition of distillation equipment to handle up to nine thousand tons per day of crude oil, de-asphalting equipment to handle the long residue prepared by vacuum distillation so that a residual waxy cylinder stock may be isolated; new de-waxing equipment coupled with solvent extraction equipment to deal with the de-asphalted waxy cylinder stock; finally increased clay treatment equipment has been necessary to deal with the de-waxed solvent-extracted cylinder stock.

To look after the increased production of white oil distillates such as motor spirit, white spirit and kerosine, the treatment side of the refinery has also needed extension, and in particular a solutizer plant and a solvent extraction plant for kerosine has been needed; while to ensure the production of the necessary quality motor spirit, both a catalytic cracking unit and a thermal reforming unit will also be included in the expansion programme.

Due to the terrain at Llandarcy it has been necessary to prepare the surface for the installation of the new process plants. To this end the hillside has been excavated so that the two flat terraces could be made available for this purpose, the uppermost terrace to house the new refinery tankage and the lower terrace to house the new process units. In all, some $\frac{1}{4}$ million cu. yards of rock and soil needed to be excavated.

Following Mr Bell's paper a lively discussion ensued in which Messrs Gilbert, Jeffreys, Bryan, Lebeau, Thomas, Hanney, Tidy, Griffiths and Jones took part. A cordial vote of thanks was proposed by Mr Gilbert and seconded by Mr Tidy.

Stanlow Branch

Two parties, each of a dozen members of the Stanlow Branch, recently

made the short trip from Ellesmere Port to neighbouring North Wales for the purpose of visiting Gresford Colliery. This is a modern undertaking at which coal was first wound in 1911; the personnel employed is about 1500 and the daily coal production over 2000 tons. Gresford is among the deeper mines, and having donned overalls, safety hats and been equipped with miners lamps (electric) the party was rapidly lowered to below 2,200 feet in the cage, gulping en route to equalize air pressure. At the bottom transfer was made to a steeply-inclined tramway; the ride on this, in cars having some resemblance to those of the Battersea Big Dipper, whilst unaccompanied by the violent changes in "*g*" associated with the latter, was considerably more interesting and lowered the visitors a further 400 feet or thereabouts. After a short walk of a few hundred yards the coal face was reached and the petroleum technologists had a first-hand view of the processes whereby solid fuel is dislodged from its strata, broken up into manageable pieces and removed, first by conveyor belt and then by tubs, to the pit bottom for hauling to the surface.

The extent and spaciousness of the underground roads proved an eye-opener to many of the visitors, even at the coal-face itself there being ample room to make ones way through without undue difficulty; however it is understood there are, even at Gresford, some smaller seams in which conditions are very different. Ventilation appeared to be first-rate; the weight of air sucked out of the mine each day is several times that of the coal removed.

On returning to the surface the impressive steam winding engine was seen, followed by an inspection of the excellent arrangements at the pit-head baths for ablution and changing from street to working-clothes and vice-versa.

After removing the coal-dust which had supplied local colour to hands and faces, the visit terminated by tea in the well-appointed canteen.

The Stanlow Branch is very much indebted to the officials concerned of the National Coal Board for enabling the members participating in this outing to enjoy what will be, for most of them, a unique experience; the visit was no superficial trip but involved, literally, getting down to earth and seeing the workings of one of our most vital industries at as close quarters as possible.

★ ★ ★

SHELL TANKER PROGRAMME

The Shell Petroleum Co. Ltd., has recently announced details of its £45 million programme of tanker building. This comprises 41 general purpose tankers of 18,000 tons deadweight and five supertankers of 28,000 tons deadweight. The general purpose tankers are of a new type, designed for maximum cargo compatible with a wide range of utility and economical operations. Four of them will be turbo-electric, each having two turbo-alternators to supply AC power for one propulsion motor.

Hull plates of all these ships will be specially treated, before painting, to combat corrosion.

The supertankers will be of similar design to the *Velutina* and will bring the total of Shell's supertankers to 14.

Comparative details of the two types are:

	New General Purpose Ship	*Supertanker ("V" Class)*
Deadweight (summer marks)	18,000	28,350
Cargo, tons	16,500/17,000	26,300/26,800
Length, overall	557ft	643ft 4in
Breadth	69ft 3in	80ft 5in
Draft (summer marks)	29ft 6in	34ft
Shaft h.p.	8,300	13,000
Service speed, knots	14½	16
Cargo pumps rating: water tons/hr	4 × 500 = 2000	4 × 500 = 2000

Of the 18,000-ton vessels, 27 are booked for U.K. yards, as are four of the supertankers. The remainder are to be built in the Netherlands.

DIESEL LOCOMOTIVE 10100

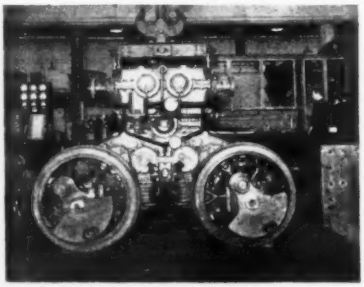
Recently British Railways have started trials of their first main-line diesel-mechanical locomotive. Previously three main-line units and over a hundred shunting units have been in operation, but all are powered by a single diesel engine and the majority have electric motor traction.

In order to overcome the difficulties experienced when electric transmission is dispensed with, locomotive 10100 was built at the Derby works of the L.M. Region. Designed by H. G. Ivatt (chief mechanical engineer, L.M.R.) and Fell Developments Ltd., this locomotive is based on new principles of power transmission.

Driving power is supplied by four Davey Paxman 12-cyl 500 h.p. supercharged engines, all auxiliary services being supplied by two 6-cyl A.E.C. engines.

The four main engines are located in pairs at the two ends of the locomotive, and each engine drives the input side of a fluid coupling. The output sides of the couplings drive through bevel gears into primary differentials. Each pair of engines is connected through the primary differential, and the two pairs are connected through a secondary differential.

Starting on one engine, the drive produces a gear ratio of 4 to 1 and as other engines are brought into operation there is a progressive change to 1 to 1 without loss of torque.



The gearbox mounted on the driving wheels.
(British Railways photo)

Diesel Locomotive 10100
(British Railways photo)

Maximum speed of this locomotive is 78 m.p.h., maximum tractive effort 25,000 lb, and the engine fuel tanks have a capacity of 720 gallons.

No 10100 is being tested on similar runs (London - Glasgow) as the diesel electric locomotives already in service, and to determine its capacity in comparison with steam engines.

★ ★ ★

"OPERATIONAL RESEARCH"

During the winter of 1949-50, the Manchester Joint Research Council arranged a series of five lectures and a concluding open forum on the subject of operational research and its application to peace-time industry. These lectures have now been reproduced in book form and Sir Raymond Streat, chairman of the Committee, suggests in the preface that they provide clues to the problem of whether operational research provides a means of raising industrial efficiency in peace time.

During the war "operational research" provided the answer to many problems, and a study of the points brought out in the lectures and in the discussions which followed should prove of value.

"Operational Research" (151 pp) is obtainable from the Manchester Joint Research Council, Chamber of Commerce, Ship Canal House, King Street, Manchester 2, price 10s 6d.

CRUDE OIL RESERVES

The latest issue of the Petroleum Information Bureau's *World Oil Reserves* indicates that at the beginning of 1951 proved reserves of crude oil in the U.S.A. were 25,268 million barrels. This was an increase of 619 million barrels over the figure for the previous year. If the reserves of natural gas liquids were added, the total would be 29,536 million barrels. The figure for world reserves of crude oil are not yet available, but on January 1, 1950, were estimated to be 80,000 million barrels.

World Oil Reserves defines the terms "proven" and "possible" in relation to reserves. It also discusses future crude oil supplies and alternative sources of oil. Copies are available from P.I.B., 29 New Bond Street, London, W.1.

★ ★ ★

U.S. PETROLEUM INDUSTRY IN 1950

Preliminary figures for the output of crude petroleum in the United States in 1950 show that there was an increase of 7.1 per cent over the final figure for 1949. Daily average production was 5,402,000 barrels. Production of natural gasoline was 15.6 per cent higher, but there was a drop of 16.4 per cent in the output of benzole. Imports of crude petroleum recorded a gain of 15.7 per cent and of refined products an increase of 60.5 per cent. Thus, there was an increase of 10.2 per cent in new supply of all oils.

Domestic demand for refined products was 12 per cent higher than in 1950, while exports of all oils declined by 7 per cent. Detailed figures, extracted from the official return of the U.S. Bureau of Mines, are given in Table I.

Crude petroleum run to stills during 1950 rose by 7.7 per cent over the 1949 total and details of the out of principal products are given in Table II.

Stocks of crude petroleum declined by 4,893,000 barrels during the year and of refined products by 16,040,000 barrels. In the case of natural gasoline there was a stock increase of 524,000 barrels.

During 1950 the number of oil wells completed was 24,430 (22,042 in 1949). There were also 2,843 gas wells (2,887 in 1949), and 14,757 dry holes (12,727 in 1949).

TABLE I

U.S. Petroleum Industry Production and Demand

	1950	1949	1948
	1,000 *barrels*		
Production			
Crude petroleum ...	1,971,845	1,841,940	2,020,185
Natural gasoline, etc.	181,558	157,086	146,721
Benzole, etc.	158	189	358
Total production ..	2,153,561	1,999,215	2,167,264
Imports			
Crude petroleum ...	177,714	153,686	129,093
Refined products ..	131,435	81,873	59,051
Total new supply	2,462,710	2,234,774	2,355,408
Exports			
Crude petroleum ...	34,798	33,069	39,736
Refined products ..	76,237	86,307	94,938
Total exports	111,035	119,376	134,674
Domestic demand			
Motor fuel	994,412	913,713	871,270
Kerosine	117,846	102,672	112,220
Distillate fuel oil ...	394,697	329,278	340,576
Residual fuel oil ...	552,944	496,021	500,543
Lubricants	38,876	33,101	35,983
Wax	3,236	2,255	2,348
Coke	15,020	14,427	11,670
Asphalt	58,685	49,362	49,962
Road oil	6,897	7,826	8,027
Still gas	83,743	82,621	81,159
Liquefied gases.....	85,121	68,238	65,508
Other miscellaneous	4,394	3,995	6,506
Losses	16,213	14,741	27,906
	2,372,084	2,118,250	2,113,678
Stocks on Dec. 31			
Crude petroleum ...	248,463	253,356	256,627
Natural gasoline ..	7,355	6,831	5,579
Refined products ..	326,892	342,932	343,537

TABLE II

U.S. Petroleum Refining Statistics

	1950	1949	1948
	1,000 *barrels*		
Crude runs to stills...	2,094,867	1,944,221	2,031,041
Refinery output			
Aviation gasoline:			
100 octane and over	39,235	35,215	33,421
Other grades.....	11,947	11,738	12,825
Motor fuel	973,266	915,464	875,677
Kerosine	118,512	102,152	121,914
Distillate fuel oil ...	398,912	340,825	380,700
Residual fuel oil ...	425,217	424,909	466,317
Lubricants	51,735	45,389	51,416
Wax*	4,462	3,208	3,515
Coke†	17,224	16,959	14,494
Asphalt‡	58,240	49,007	51,919
Road oil	6,928	7,691	7,915
Still gas§	83,743	82,621	81,159
Liquefied gases.....	33,800	27,705	30,605

*1 brl = 280 lb.
†5 brl = 1 short ton.
‡5·5 brl = 1 short ton.
§1 brl = 3,600 cu. ft.

"ARCHIE"

In a stylized form, as depicted in the Institute's crest, "Archie" the Archaeopteryx is familiar to all members. Now it is possible to see how he appeared as he flapped clumsily about his business 120 million years ago.

A life-size model of the Archaeopteryx, which was about as big as a crow, is now displayed in the Bird Gallery of the National History Museum, London, the Museum's chief taxidermist, A. G. Hayward having based his reconstruction on the fossil skeleton from the Jurassic limestone of Bavaria.

The Archaeopteryx, the earliest known feathered animal, had heavy wings which had not yet developed sufficiently for it to fly strongly. Indeed, the Museum says, it may have used its clawed fingers to climb to a height from which to launch itself into a glide. Though very bird-like, it retained certain features of its reptilian ancestors, such as toothed jaws and long jointed tail.

The fossil skeleton, of course, gave no clue to colour, but Mr Hayward decided that as its scales had only recently turned into feathers, they were not likely to have had time to develop from the dull colours of scales into the bright colours of the modern bird. Therefore the Archaeopteryx was probably dark brown and Mr Hayward used feathers from the stomach of a pheasant, the wings of a pigeon, and the back of a cormorant. It took him the better part of a year to insert these feathers, one by one, into the wax-covered wooden foundation of the body.

The Archaeopteryx at the Natural History Museum. (Crown Copyright reserved)

★ ★ ★

COMPANY PRODUCTION
CRUDE OIL

	May 1951 brl
Trinidad Petroleum Development Co. Ltd.	251,830
British Controlled Oilfields :	
Venezuela :	
Western area ...	13,032
Central area	17,336

Persian production. Production of crude oil in Persia for the month of April, 1951, amounted to 2,217,000 tons, total production for the period January 1 to April 30 being 10,258,000 tons.

Kuwait Crude : Production of crude oil in Kuwait for the month of April 1951 amounted to 2,038, 205 tons, total production for the period January 1 to April 30 being 6,736,104 tons.

"ELECTRIC EYES"

The uses, advantages and disadvantages of the photo-electric cell are described in concise, simple language in a 28-page booklet entitled "Electric Eyes." After illustrated examples have been given of some of the more important uses of the photo-electric cells—for instance as a counting device, in burglar alarms and for smoke detection—the question of the application of the photo-electric cell in the field of colorimetry is discussed in detail. A useful glossary of terminology is included. The booklet is published by The Tintometer Ltd., Salisbury, Wilts, at 1s 6d.

PETROLEUM IN PARLIAMENT

Exports to Hong Kong

Replying to a question on May 31, the President of the Board of Trade said: In the period January to April, 1950, 61,000 gallons of refined petroleum and lubricating oil and 170 tons of lubricating greases were exported from the United Kingdom to Hong Kong. For January—April, 1951, the corresponding figures were 260,000 gallons and 310 tons respectively. There were no exports of motor spirit, gas oil, fuel oil or diesel oil. It is necessary to add that the United States placed an embargo on all exports to Hong Kong on December 3, 1950, and it was therefore necessary for the United Kingdom to send additional supplies of oil and lubricating greases to Hong Kong for local consumption.

Caribbean Refineries

Asked about the expansion of refining capacity in British Caribbean territories, the Minister of Fuel and Power said on June 4: Trinidad is the only British territory in the Caribbean where refining is done. During the last three years, the Trinidad Leaseholds Company has increased the output of its refinery at Point-a-Pierre by about one third; it is now about 3,250,000 tons a year. The plant is being modernised and a catalytic cracking unit is being put up. When this work is done the plant will produce a wide range of high quality products.

Answering a supplementary question as to whether consideration was being given to establishing refineries in other British West Indian islands, the Minister said: There are, in fact, British controlled company refineries in Venezuela and Curacao and Shell have a refinery in Trinidad; but the companies now prefer to erect refineries near the point of consumption.

Coupons

Coupons for petrol rationing have been printed as an insurance against any future emergency that may arise. They do not, therefore, relate to any specific period, said the Minister of Fuel and Power on June 4.

Middle East (Locusts)

Following the Persian government's appeal for aid in meeting the locust threat, the Anglo-Iranian Oil Co, in consulation with H.M.G., had immediately made available to the Persian government spraying aircraft, insecticide, expert personnel and service, to a total cost of £75,000, said the Under Secretary of State for Foreign Affairs (June 4).

★ ★ ★

£7,500,000 TANKER ORDER

Contracts, the value of which exceeds seven and a half million pounds, for six new oil tankers each 26,500 tons deadweight, have been placed with British shipbuilders by the Esso Petroleum Co. Ltd.

Three of the new ships are to be built by Cammell Lairds at Birkenhead, two by Vickers Armstrongs at Walker's yard, Newcastle-on-Tyne, and one by John-Brown's at Clydebank.

Four of the ships will be used to transport sterling crude oil from Middle East sources to the Fawley refinery and the remaining two ships will be for the Standard-Vacuum Oil Co. for their trade in the sterling area.

The new tankers will be 628 ft overall in length, 600 ft between perpendiculars, 82½ ft moulded breadth and 42½ ft deep, with summer draft 31 ft 11 inches, and will have a designed speed of seventeen knots. The propelling machinery will consist of a reduction gear turbine of 1250 s.h.p. driving a single screw.

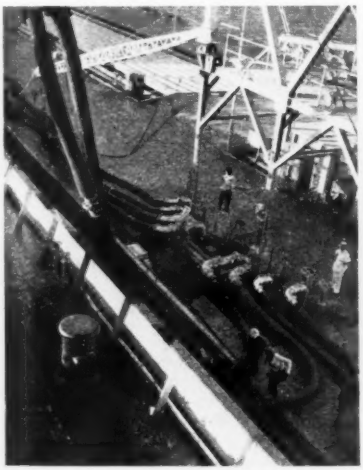
TANKER PICTURES

Recently an interesting photographic exhibition on the Modern Oil Tanker was presented by the Anglo-Saxon Petroleum Co. Ltd. in co-operation with Lloyds, London, as a tribute to the research work of marine designers, to the constructional skill of British shipbuilders, and to the men of the tanker fleet.

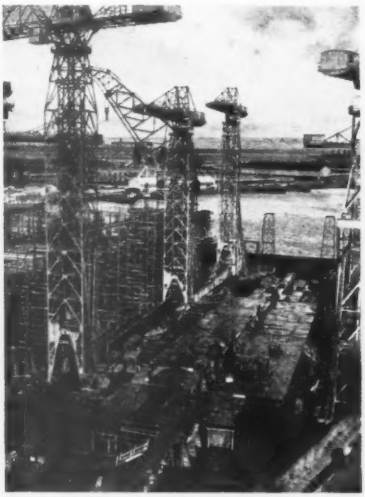
Sunshine over the bow of Velutina. (Shell photos)

These pictures covered every aspect of tanker construction and operation. They illustrated the various steps in the building of a modern tanker, the engineering work necessitated in the construction of propelling machinery, etc., the training of crew and officers, the amenities provided for the crew during their journeys across the ocean, and the facilities provided for their recreation.

In descriptive matter published in connexion with the exhibition, it was pointed out that it was not until 1885 that the principle of using the hull of a vessel for transportation of oil in bulk was adopted. S.S. *Murex* was the first of the Shell fleet, being completed in 1892, with a length of 338 ft and 5,010 tons deadweight. The latest additions to this fleet are the four 28,000-tons deadweight tankers of approximately 643 ft in length, primarily designed to carry crude oil from the Middle East to Britain.



Velutina collects her first cargo.



Building a 28,000-ton tanker.

"KNOW-HOW"

This useful term has only recently attained the status of recognition by the Oxford English dictionary, being given in the latest (4th, 1951) edition of the Concise version, although the expression "to know how," in the sense of being able to, is stated by the Shorter O.E.D. to date from 1548. However, the noun has now been (more or less) accepted in the precincts of Lincolns Inn, having found its way into the staid pages of *The Conveyancer and Property Lawyer*, although not without an explanatory note of apology from the Editor to his readers.

In the issue of that periodical for March/April, 1951 there is to be found a most informative article entitled *Agreement for the Sale of "Know-How"* by T. A. Blanco White.* In this the author discusses technical information as a saleable commodity and points out the difference between an agreement which is in the form of a patent licence, with the purveyance of "know-how" as an incidental feature, and a transaction in which the conveying of technical assistance of this type is the main object.

*Reprinted as a separate pamphlet (Sweet and Maxwell, Ltd., 2/3 Chancery Lane, London, W.C.2. 1/-).

In such cases it may well be preferable to omit any mention at all of patents from the contract between the parties; such omission may be of very definite advantage to the seller if there is any chance, as so often happens even with an invention which is of genuine industrial value, of the patent being declared invalid for one of the many reasons possible in patent law.

Agreements involving the transfer of "know-how" are very frequent in the oil industry and those of our readers who may be concerned in arrangements of this type will find Mr Blanco White's treatment of this problem of considerable interest and assistance. In addition to discussing the various legal aspects involved, the author has drafted a detailed precedent (to use the legal term for a specimen agreement) which relates "to an agreement between the Alpha Corporation and Beta Ltd., under which Alpha, who have much knowledge and experience of the manufacture of gammas, are to assist Beta to establish in the United Kingdom a new gamma-making plant." From this description of the precedent the possibility of its application to transactions concerning petroleum processing is evident.

V.B.

Group - Captain Douglas Bader, D.S.O., D.F.C., accepts delivery of a Miles Gemini four-seater aircraft, to replace the single-engined aircraft in which he covered 120,000 miles during the last three years to inspect Shell's aviation ground organization in the Eastern hemisphere. On the right is R. R. Paine, a director of Wolverhampton Aviation Ltd.

PERSIA AND THE PERSIANS

An intelligent and observant woman, who married a Persian poet, went to live in his country, mastered the language and acquired a deep affection for its people, gives an unusual peep behind the Persian scene in "I Sing in the Wilderness."* The author, Olive Suratgar, first arrived in Teheran in 1936, when the modernization of the country under Reza Shah was in full swing and she had quickly to learn to curb her Yorkshire forthrightness, lest an indiscreet remark should bring her husband into political disfavour.

Even before she went to Persia, the author learnt from her fiancé the Persian viewpoint on the 60-years oil concession. "Far from regarding the company as a kindly mother (the Persians) saw it as a ruthless exploiter to whom they had sold this birthright."

In the middle thirties, after the 1933 agreement, Mrs Suratgar heard little adverse criticism from the Persians. Houses, sanitation, hospitals, and clinics were provided both at Abadan and in the fields and the growing number of Persians employed by the company eased the ecomonic situation. Even then, senior Persian officials had a grievance—a kind of inferiority complex. When they went to Abadan, with its English atmosphere they felt they were foreigners in their own land.

After the last war the situation deteriorated rapidly. Giving both sides of the picture the author says "No patriot can watch this steady drain (of oil) without asking himself whether his country is getting an equitable *quid pro quo*." And on the other side "A visit to Abadan and its fields should convince any but the most biased opinion that the A.I.O.C. has been something more than an exploiter".

*Edward Stanford, Ltd., 12s 6d.

PERSONAL NOTES

Robert H. Cairn, V.C., has been appointed general manager of the Shell Company of West Africa Ltd. Mr Cairn, then a Major in the 1st Airborne Division, won the Victoria Cross at Arnham. Prior to his present posting he was in Malaya.

A. Hyman, assistant general manager and operations manager of Shell-Mex & B.P. Ltd., since 1947, has retired. Mr Hyman joined the development department of Shell-Mex in 1924. During the last war he was manager of the Inland Distribution department of the Petroleum Board.

T. C. G. Thorpe, F.Inst.Pet., has become assistant manager, Industrial Sales department of the Esso Petroleum Co. Previously he held the post of co-ordinator, Industrial Lubricants. Mr Thorpe joined the company in 1930.

★ ★ ★

NEW OIL COMMITTEE

A new body, called the Oil Supply Advisory Committee, has been formed by the Shell Petroleum Co. Ltd., the Anglo-Iranian Oil Co. Ltd., and Trinidad Leaseholds Ltd. It will advise H.M. Government on oil supply problems, with particular reference to defence. The Committee is entirely an industrial affair, members being Sir William Fraser, C.B.E. (Chairman), Sir George Legh-Jones and Mr S. Vos. Committee Secretary is J. P. Berkin of Shell Petroleum Co. Ltd.

U.K. PETROLEUM CONSUMPTION

During 1950 the total consumption of petroleum products in the U.K. was 15,276,771 tons, an increase of 10 per cent over the 1949 total of 13,839,727 tons.

The details in Table I are taken from a pamphlet issued by the Petroleum Information Bureau on behalf of the U.K. Petroleum Industry Advisory Committee.

TABLE I.
PETROLEUM CONSUMPTION IN THE U.K.

	1949	1950
	Tons	
Aviation spirit	287,506	281,989
Motor Spirit*	4,671,395	5,195,173
Industrial Spirits†	64,905	80,667
White Spirit	148,513	148,994
Kerosine‡	1,525,202	1,539,024
Derv Fuel	924,350	1,034,103
Gas, diesel, and fuel oils :		
Burning	2,645,691	2,882,140
Power	874,281	1,018,466
Gas manufacture	509,883	539,611
Refinery consumption	499,045	649,775
Petrol industry consumption	122,886	118,057
Other uses	130,871	129,742
Lubricants	714,274	748,796
Paraffin wax and scale	40,242	43,177
Butane and propane	23,498	30,251
Bitumen	545,262	621,281
Miscellaneous	111,923	215,525
	13,839,727	15,276,771

*Including motor benzole

†Including industrial benzole

‡Including aviation turbine fuel, burning oil, and vaporizing oil.

★ ★ ★

INLAND DISTRIBUTION OF OIL

A memorandum from the Petroleum Information Bureau deals with the internal distribution of refined products, with particular reference to the system as it operates in the U.K. Copies from P.I.B., 29 New Bond Street, London, W.1.

Details of production of refined products from imported and indigenous crudes and process oils, including shale oil, are given in Table II.

TABLE II
U.K. REFINERY OUTPUT

	1949	1950
	Tons	
Motor and aviation spirits	870,138	1,477,955
Industrial and white spirits	51,163	52,227
Burning and vaporizing oil	127,968	160,496
Gas and diesel oil	1,192,212	1,890,745
Fuel oil	2,780,086	4,344,740
Bitumen	554,759	636,085
Paraffin wax,etc.	14,810	15,563
Lubricating oil	375,956	427,288
Propane and butane	20,941	23,736
Miscellaneous	175,757	254,917
	6,163,790	9,283,752

★ ★ ★

WILDCATS IN SARAWAK

Two test wells are being drilled by Shell at Bulak Setap and at Subis in Sarawak, British Borneo. They are located in the forest, some 10-12 miles inland, and south of the long-established Miri field. Drilling is already in progress at Subis, to which site equipment, stores and personnel can be taken up the narrow Niah river in shallow-draft craft.

Bulak Setap, however, lacks the advantage of a nearby navigable river and it has been necessary to construct a 30-mile road from Miri at a cost of nearly £200,000.

Geological and geophysical surveys are meantime being carried out over wide areas of Sarawak territory.

★ ★ ★

Ethylene Oxide : "The Handling and Storage of Ethylene Oxide" is the subject of Petrochemicals Ltd's Technical Service Leaflet No 2. Copies are obtainable from their Sales Dept., 170, Piccadily, London, W.1.

DRILLING IN PAKISTAN

Encouraging shows of oil were met during May in Pakistan Petroleum's Test Well No. 4 at Chakwal (Punjab) at a depth of 8212 feet.

Drilling operations started at this well on January 27, 1950, and a depth of 5,176 ft was reached within 3 months of the beginning of operations. When the well was 6,495 feet deep an unexpected water sand of very high pressure and volume was met which greatly delayed progress. It was only by the end of 1950 that it became possible to drill through this high pressure water sand.

In March 1951, the well was deepened to 8061 feet to drill into the Sakesar Limestone but indications of oil were very disappointing.

The depth where oil shows were met in No. 4 well is the same as that of Pakistan Petroleum Ltd's well No. 2 where oil was struck in June 1949.

Test well No. 3 was abandoned as a dry hole early this year.

Though well No. 3 had penetrated to the same depth as well No. 2, it failed to give worthwhile production. Three treatments with hydrochloric acid to open up the pores of the sandstone were given without any success and it was therefore decided to "shoot" the well with the object of shattering the formation. About 500 lb of Ardex explosive were fired successfully but without any material improvement in production. Two further acid treatments were given, but also without success.

The well was deepened through the Sakesar Limestone in the hope that at a greater depth it might strike commercial production.

At a depth of 8939 feet another shooting was done but without any sign of improvement and when swabbing of the well failed to show any production, the well was finally shut down as a dry hole, as previously had been Chakwal Test Well No. 1.

★ ★ ★

Scientific Film Congress: The 5th Congress of the International Scientific Film Association is to be held at the Hague from September 15 to 22, 1951. Those who wish to submit films for showing should send full details including short synopsis, gauge, running time, and date of production to the Association at 4, Great Russell Street, London, W.C.1.

A Chemical Industry Management Conference was recently held at Brighton by Shell. It was attended by delegates from all over the world. Here are (L. to R.) R. F. H. Braybrook (France), A. D. Koeleman (C.I.M.)., J. L. van Krimpen (B.P.M., The Hague), W. F. Mitchell (C.I.M.)., L. V. Steck (Shell Chemical Corpn, U.S.A.)

INDIAN PETROLEUM PRODUCTION

Official figures for the production of petroleum products in India during 1947 and 1948 are:

	1947	1948
	Gallons	
Motor spirit, etc	19,234,722	17,848,519
Kerosine	14,266,242	11,132,632
Distillate fuels	11,114,453	14,933,821
Wax	9,173,869	9,995,652
Bitumen	231,270	621,242
Sundry oils	6,909,092	8,027,543
Coke	2,379,841	2,096,911
	63,309,489	64,656,320

Production of crude petroleum in 1948 was 65,607,982 gallons and total consumption of refined products was 537,851,592 gallons. Of the latter, 483,190,924 gallons was imported.

★ ★ ★

HINTS ON OVERSEAS TRAVEL

Three leaflets intended to help overseas travellers, and covering the Caribbean, the Middle East, and North America, have been compiled by the Overseas Advisory Committee of the Council of British Manufacturers of Petroleum Equipment. The leaflets are based on recent on-the-spot experience of members of the Committee, who also offer personally to advise representatives of member firms travelling overseas.

In a pocket-size folder, accompanied by maps, the three leaflets cost 10s 6d. from the Offices of C.B.M.B.E., 79 Buckingham Palace Road, London, S.W.1.

★ ★ ★

CARBON BLACK EXPANSION

Expansion plants, which are designed to double their present production of carbon black, have been announced by Cabot Carbon Ltd. A new unit of their Ellesmere Port factory is to be built which should result in a total annual capacity of 40 million pounds.

The new unit will produce primarily HAF (high abrasion furnace) grades of carbon blacks, best suited to the full reinforcement of rubber.

Construction will probably require at least a year.

At the Shell Fleet Retired Staff Reunion Dinner. Sir George Legh-Jones, M.B.E. is speaking. Also seen, (L. to R.) Chief Engineer G. Armstrong (Chairman of the Association, 1951-2), Capt. H. Jackson, C.B.E., Jhr H.G.A. Quarles van Ufford (President of the Club of Netherlands Retired Masters and Chief Engineers), Capt. G. A. Dawson, O.B.E., Chief Engineer D. Ewan, O.B.E., (The Anglo-Saxon Petroleum Co. Fleet).

INDUSTRIAL CHEMISTRY CONGRESS

The 24th International Congress of Industrial Chemistry is to be held in Paris from November 25 to December 1, 1951. The Congress will be divided into 19 working sections, which include (5) Liquid, solid and gaseous fuels; (9) Cements, asphalt, bitumens etc; (13) Natural and synthetic resins, rubber, paints, varnishes, etc; (18) Fertilizers, insecticides etc; Authors are invited to submit papers, which should be sent, not later than September 15, to XXIV Congrès International de Chimie Industrielle, Société de Chimie Industrelle, 28, Rue Saint Dominique, Paris VII, to whom all enquiries should be addressed.

★ ★ ★

INSTRUMENT MAINTENANCE

A new scheme of courses and examinations for Instrument Maintenance mechanics has recently been adopted by the City and Guilds of London Institute. The scheme is intended to meet the needs of mechanics and technicians concerned in the maintenance, repair and installation of the instruments used for process and production control, and the petroleum industry is among those to whose requirements particular attention is given.

Information about the scheme may be obtained from the City and Guilds of London Institute, Department of Technology, 31 Brechin Place, London, S.W.7.

★ ★ ★

A.I.C.E. MEETING

The annual meeting of the American Institute of Chemical Engineers will take place at Chalfonte-Haddon Hall, Atlantic City, N.J., from December 2-5, 1951.

APPOINTMENTS VACANT

ESSO PETROLEUM COMPANY LTD. have vacancies for **CHEMISTS** and **CHEMICAL ENGINEERS** in the following SUPERVISORY POSTS at their New Refinery at Fawley, near Southampton.

Candidates should have a good honours degree and preference will be given to those with petroleum experience. These posts are pensionable.

A. ASSISTANT CHIEF CHEMIST.

Candidates should have a good honours degree, experience of supervising a laboratory with graduate and non-graduate staff engaged upon quality control and plant research work related to the manufacture of a wide range of petroleum products.

B. PROCESS ENGINEER TO TAKE CHARGE OF CRACKING SECTION TECHNICAL SERVICE DEPT.

Candidates should preferably have experience of design and plant problem work on thermal and catalytic cracking units.

C. PROCESS ENGINEER TO TAKE CHARGE OF LUBRICATING OILS SECTION TECHNICAL SALES DEPT.

Candidates should preferably have design and plant problem experience on lubricating oil processing plant.

APPLICATIONS, stating age, qualifications, experience and salary required, should be sent to the Employee Relations Superintendent, Esso Petroleum Co. Ltd., Fawley, Southampton.

★ ★ ★

Russian journals. A cross-index to the English translation of the *Journal of General Chemistry of the U.S.S.R.* (Vol. 19, 1949) has been published, and can be purchased separately by non-subscribers for $2.50 from the publishers, Consultants Bureau, 152, West 42nd Street, New York 18. As well as the *Journal of General Chemistry*, which in its English translation costs $95.00 a year. Consultants Bureau also publishes *Journal of Applied Chemistry of the U.S.S.R.* in English translation (price $80.00 per year.

The
LOVIBOND COMPARATOR

with permanent glass colour standards
for the new S.T.P.T.C. benzole tests:
CARBON DISULPHIDE
THIOPHEN
CORROSIVE SULPHUR

ALL AVAILABLE FROM STOCK

SOLE MAKERS: **THE TINTOMETER LIMITED, SALISBURY, WILTS.**

Always Specify E-Mil

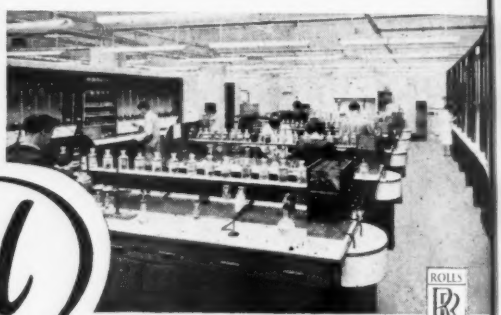
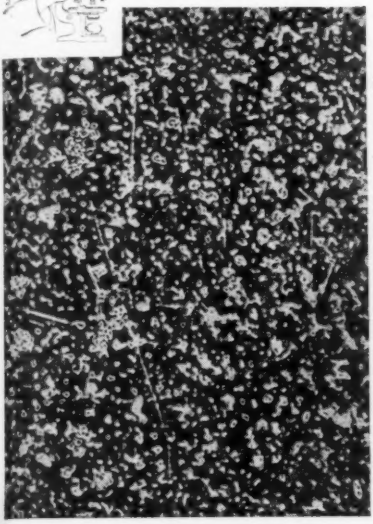


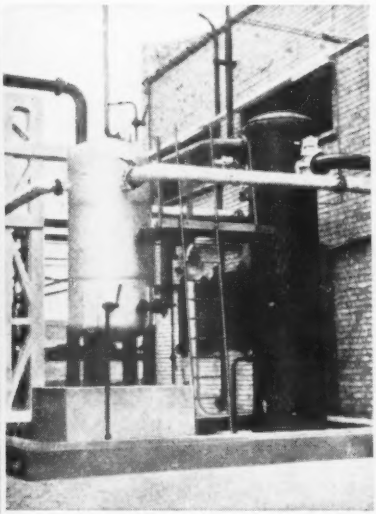
Illustration of Analytical Laboratory of Rolls Royce, Derby, where the use of E-Mil apparatus and thermometers meets the high degree of quality and accuracy demanded in their exacting research and general laboratory work.

and be ***assured*** of the **FINEST Laboratory Glassware and Thermometers**

H. J. ELLIOTT LTD., E-Mil Works, Treforest, Nr. Pontypridd, Glam.

Take a good look at 85% Magnesia





Crystal formation—maximum heat retention

The regular crystal formation (exclusive to Magnesia insulation) breaks up the air into millions of tiny pockets. This is the structure that is saving 90% of heat loss and making Darlington Magnesia the most efficient insulation for temperature control in refining plant.

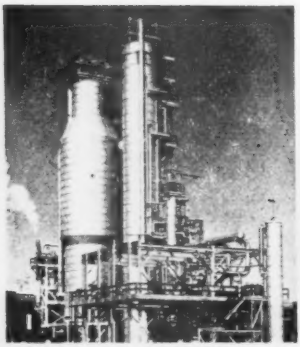
DARLINGTON
85% MAGNESIA
Insulation

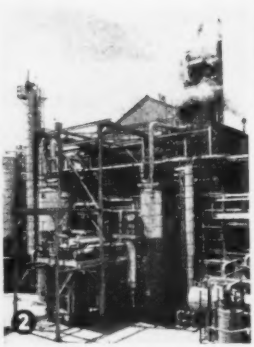
YOU HAVE A PROBLEM. The technical division of the Darlington group of companies will design and install an insulation scheme to meet your needs.

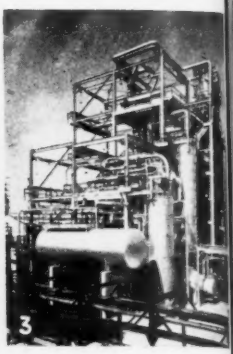
Manufacturers
THE CHEMICAL & INSULATING CO., LTD., DARLINGTON
Insulation Contractors: THE DARLINGTON INSULATION CO., LTD., NEWCASTLE UPON TYNE.
Sheet Metal Fabricators: S. T. TAYLOR & SONS, LTD., TEAM VALLEY, GATESHEAD.

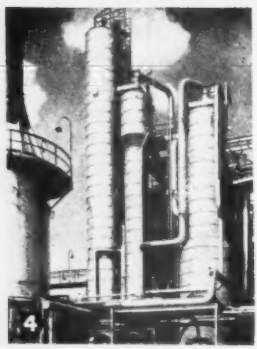
SB240D

Proof of Satisfaction









1 Atmospheric-Vacuum Crude Distillation

2 M.E.K. Dewaxing

3 Propane Deasphalting with Mod·fier

4 Furfural Extraction

This crude distillation and lube o finishing program plus gasoline and treating facili ties, recently completed, represent a continuatio of Badger services to the same client over a perio of many years. Badger regard repeat orders as funda mental indication client satisfactio

E. B. BADGER & SONS (GREAT BRITAIN) LTD.

99 ALDWYCH LONDON W.C.2

Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries

SWITCH AND CONTROL GEAR

CHIEF PRODUCTS

CONTACTOR STARTERS

TOTALLY ENCLOSED
UP TO 450 H.P AT 660 V.
UP TO 250 H.P. AT 3,300 V.

FLAMEPROOF
UP TO 300 H.P. AT 660 V.
UP TO 250 H.P. AT 3,300 V.

MINING SWITCHGEAR

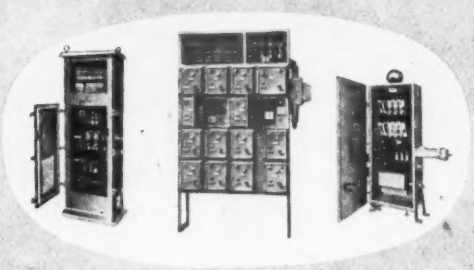
A COMPREHENSIVE RANGE OF CONTROL GEAR AND ACCESSORIES FOR COAL-CUTTERS, CONVEYORS, LOADERS, DRILLS AND HAULAGE.

OIL-BREAK SWITCHGEAR

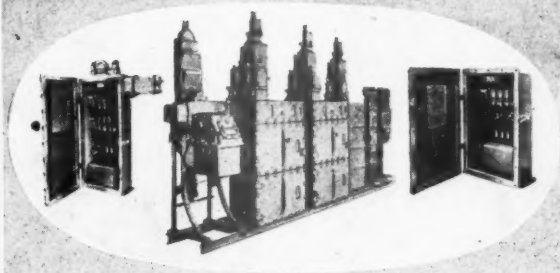
TOTALLY ENCLOSED
UP TO 3,000 AMPS. AT 660 V.
UP TO 400 AMPS. AT 3,300 V.

FLAMEPROOF
UP TO 400 AMPS. AT 660 V.
UP TO 400 AMPS. AT 3,300 V.

• A.C. CONTACTOR STARTERS •



TOTALLY ENCLOSED



FLAMEPROOF

• STRAIGHT-ON, STAR-DELTA AND STATOR-ROTOR CONTACTOR STARTERS, AVAILABLE IN TOTALLY ENCLOSED, HOSEPROOF AND FLAMEPROOF ENCLOSURES, CAN BE SUPPLIED AS SINGLE OR MULTI-UNIT ASSEMBLIES.

M.&C. SWITCHGEAR LTD.,
KIRKINTILLOCH, GLASGOW.

Telephone:
Clerkenwell 2908

Telegraphic Address:
"Gasthermo, Barb, London"

The mark of precision and efficiency
BRITISH MADE THROUGHOUT

B. BLACK & SON, LTD.

180 Goswell Road, London, E.C.1

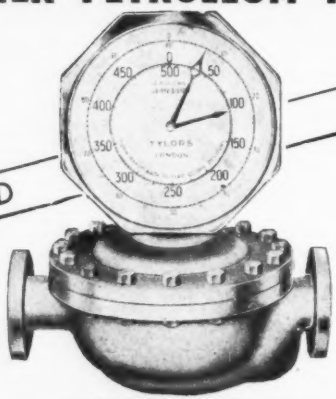
MANUFACTURERS OF LABORATORY THERMOMETERS

Fluid-in-Glass Thermometers graduated on stem, for determining temperatures between — 200/+550 C. with an accuracy, corrections and permanency well within the limits permissible to obtain N.P.L. Certificates.

The filling in the etchings is heat resisting and is insoluble in all solvents with the exception of those that attack the glass itself.

MAKERS OF THERMOMETERS TO ALL SPECIFICATIONS FOR PETROLEUM TESTS

VOLUMETERS FOR OIL, PETROL AND OTHER PETROLEUM PRODUCTS



ACCURACY MAINTAINED

BALANCED PERFORMANCE RUGGED CONSTRUCTION

APPROVED BY THE BOARD OF TRADE (Standards Department)

TYLORS LIMITED

BELLE ISLE
LONDON, N.7

ESTAELISHED 1777

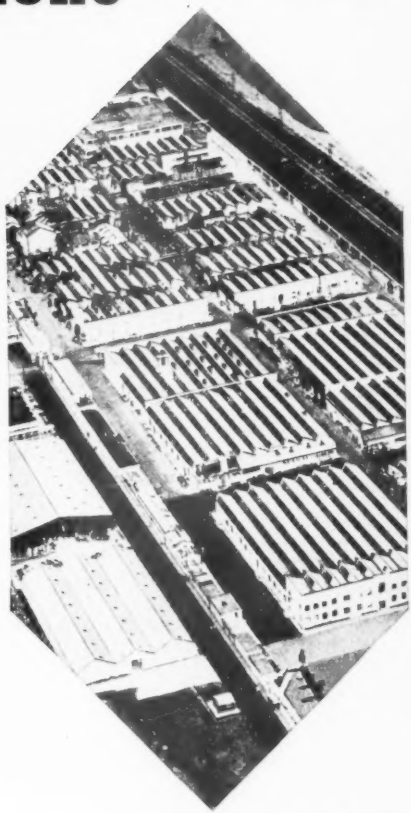
'PHONE: NORTH 1625

Hydroquinone

- **M&B**

Hydroquinone finds wide use in industry where its properties as a stabilizer and anti-oxidant have proved invaluable in a number of applications.

Hydroquinone—M&B is manufactured at Dagenham in the largest and most up-to-date plant of its kind in Europe. The required high standards of purity and uniformity are assured by a rigid system of analytical control.



MAY & BAKER LTD DAGENHAM

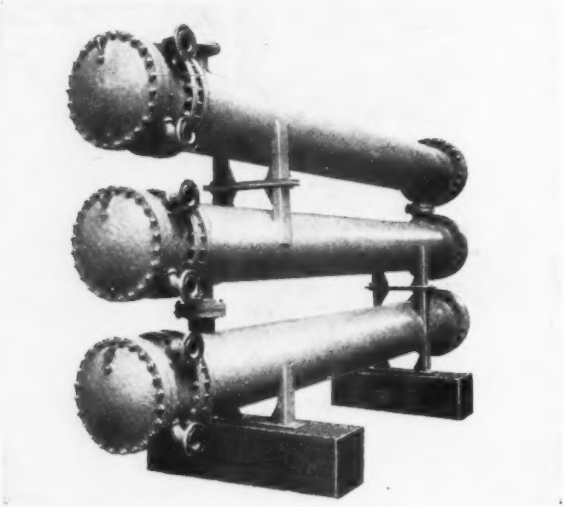
Telephone : ILFord 3060 *Extension 219*

Associated Houses · Sydney · Bombay · Port Elizabeth
Montreal · Wellington · Lagos

Branches and Agents throughout the World

CH3294

Heat Exchange Equipment



GAS OIL/CRUDE HEAT EXCHANGERS
Total Surface - - - - - - - 1680 sq. ft.

We are specialists in the design and fabrication of all types of heat exchangers and shall be pleased to submit proposals to meet your most exacting requirements.

Let us solve your heat exchange problems to your entire satisfaction.

A. F. CRAIG & CO., LTD.

CALEDONIA ENGINEERING WORKS
PAISLEY SCOTLAND

London Office 727 Salisbury House, London Wall, E.C.2. *Telephone:* MONARCH 4756

American Associates :
THE KOCH ENGINEERING COMPANY, INC., WICHITA, KANSAS

Richmond Hill Printing Works, Ltd., Bournemouth

For precision viscometry . . .

Gallenkamp

THERMOSTATIC WATER-BATHS

For use in the determination of kinematic viscosity by the capillary viscosity method. Suitable for methods described in I.P. 71/47 (T), B.S. 188, and A.S.T.M. D.445-46 (T).

Full particulars sent on request

A. GALLENKAMP & Co., LTD.

Manufacturers of Modern Laboratory Equipment and Scientific Apparatus

17-29 SUN STREET, LONDON, E.C.2

Packaging at your finger-tips

Wherever you want your products to go, and whatever method of transport you employ, there is a Metal Container to carry them safely.

METAL CONTAINERS

METAL CONTAINERS LTD., 17 WATERLOO PLACE, PALL MALL, LONDO

WORKS: ELLESMERE PORT & RENFREW ASSOCIATED COMPANIES OVERSEA

NDO
ERSEA